CHAPTER: 1.6.

Quinoa and the exchange of genetic resources: improving the regulation systems

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Abstract

As proposed by FAO, the General Assembly of the United Nations declared 2013 as the International Year of Quinoa (IYQ), highlighting the potential role of quinoa's biodiversity in contributing to global food security, given its high nutritional value and tremendous potential to adapt to different agro-climatic conditions. The declaration recognizes the role of the Andean communities in creating this biodiversity and conserving numerous local varieties of quinoa. The cultivation of quinoa on other continents will continue to expand in the coming years, and there will be an increasingly widespread distribution of systems of intellectual property rights (IPR) governing varieties or genes. It is, therefore, essential to recognize the contribution made by the Andean communities, applying measures to guarantee the fair and equitable sharing of the benefits derived from the use of quinoa's genetic resources and associated traditional knowledge. This chapter addresses these issues.

Four main targets can be identified: recognition of the Andean identity of quinoa's genetic resources and the associated traditional knowledge; conservation of the components of biological diversity and ecosystems; sustainable and effective use of quinoa's genetic resources in order to encourage innovation; fair and equitable sharing of the benefits derived from the use of these resources and associated traditional knowledge.

The existing international frameworks do not address these issues in a satisfactory way. The CBD and the Nagoya Protocol regulate bilateral access and benefit-sharing. However, quinoa's genetic resources are transboundary and for decades they have been disseminated outside the Andean zone.

The International Treaty on Plant Genetic Resources for Food and Agriculture (Treaty) addresses these various objectives but does not cover the many different non-agricultural and non-food uses of quinoa (medicinal applications, cosmetics etc.). It also fails to address adequately (at least so far) the in situ conservation dimension — a critical aspect for the fair and equitable sharing of benefits derived from the use of quinoa with the Andean populations. Intellectual property rights, even those that are sui generis, including plant variety protection (PVP) certificates, geographical indications and collective trademarks, mainly focus on encouraging innovation. They are temporary (of limited duration and validity) and are not recognized by all countries. IPR mechanisms do not address the conservation of genetic resources and alternative solutions are required. Soft laws instruments such as the FAO's Globally Important Agricultural Heritage Systems (GIAHS) and biocultural landscapes deals with in situ conservation for the protection of agrarian systems that enrich biodiversity. Nevertheless, they are unsuitable for dealing with ex situ biodiversity conservation and the fair and equitable sharing of the benefits derived from the use of genetic resources. Although the Open Source Seed Initiative seems to provide an interesting alternative mechanism for the multiple stakeholders involved in different stages of production, selection, diffusion and conservation, it lacks a legal structure which would allow it to protect the exchange of genetic material and prevent misapropriation. However, these systems do not include wild crop relatives. They focus predominantly on varieties of the cultivated species.

Consequently, there is no single legal framework capable at this stage of dealing simultaneously and globally with the four areas identified. The gaps in each of these instruments are an incentive for improvement. Solutions still need to be developed to better harmonize the different existing legal frameworks and soft laws mechanisms and/or create new complementary ones. The rapid spread of quinoa at global level provides an opportunity to consider the implications of the current regulatory instruments for genetic resources so that they can be improved and implemented anew.

Introduction

At present, just 12% of the main crop species cultivated provide 75% of our food. Of these, wheat, rice and maize provide 60% of the calories consumed in the world (FAO, 2010).

All countries are now increasingly interdependent for meeting their food and agricultural requirements. It should be noted that over the past 10 000 years, since the emergence of agriculture, the world's agrarian societies have created and developed agricultural plant genetic resources in five main centres of origin: the Near East (barley and wheat); southern Asia (rice); Africa (millet and sorghum); Central America (maize); and South America (potato and quinoa) (Bazile, 2012).

The history of the domestication of cultivated plants that has led to their world expansion goes back a long way and is linked to several periods of agricultural development (Bazile, Fuentes and Mujica, 2013). The genetic resources of cultivated plants have been collected and exchanged locally or via human migration for over 10 000 years. These species are now cultivated on vast areas of land throughout the world. Furthermore, they are considered the main crops for agricultural production and world food security.

The genetic resources of the main crop species have been and continue to be the focus of major plant breeding research associated with processes of ex situ conservation. In the case of "secondary" food species, the creation of genetic diversity occurs via a continuous process in the field. Farmers are constantly looking to introduce new genetic material in order to avoid low productivity of their own varieties reproduced each year. Low quality observed in seeds is often resulting in a decrease in productivity due to the degeneration of the genetic material caused by cross-pollination with other local varieties.

To guarantee these dynamics of change, the dissemination of plant genetic resources is based on principles of free access and distribution. In the light of recent advances in biotechnology, intellectual property rights (primarily patents) are being extended to the genetic resources of living organisms based on principles of ownership and exclusivity. This defines the standards governing the movement of improved varieties produced by both private and public breeders of new plant varieties (Bazile, 2011).

In this context, the case of quinoa is highlighted. It is a crop located in Andean countries, which is spreading to numerous countries across all the continents and has the potential to become a main crop in world agriculture (Galwey, 1993; Jacobsen, 2003; NRC, 1989). At global level, the rapid expansion of the areas where it is grown led FAO to declare 2013 as the International Year of Quinoa. It is rare for a crop of regional status, and considered as minor crop, to obtain such world recognition. This situation must be emphasized.

The evident change in status of this species, which was domesticated on the shores of Lake Titicaca, may provide a model for examining and analysing the current legal regulatory frameworks for genetic resources.

In fact, potato (Solanum tuberosum sp.) ranks fourth among the world's main food crops. Like quinoa, potato originates from the Andes, in the Lake Titicaca basin, where it was first cultivated over 8 000 years ago.

Andean farmers had access to a large wild population from which they were able to select and improve the first specimens, which thousands of years later have produced the tremendous diversity of potato species and varieties known today.

The genetic diversity of Solanum tuberosum is divided into two subspecies: the first, andigena, is adapted to a photoperiod of 12 hours of sunlight and is mainly cultivated in the Andean region; the second, tuberosum, is grown throughout the world. The tuberosum subspecies will have developed from andigena, which was introduced in Europe long ago and gradually adapted to the Northern Hemisphere with its longer days.

Nowadays, approximately 5 000 local potato varieties are grown in the Andes. The new potato varieties are cultivated mostly in Asia and Europe and currently account for over 80% of world production (Alary et al., 2009). Europeans are the world's biggest potato consumers – 85 kg per person in 2009 (FAOSTAT).

Although the evolution of potato's global distribution took place in a different period, it could shed light on the trajectory of quinoa's current spread across the world. When examining the existing legal regulatory frameworks, potato could be a useful reference to determine whether or not these processes will be repeated. This historical insight provides the opportunity to see how new legal regulatory frameworks can be applied to genetic resources (Trommetter, 2001, 2012).

At present, industrialized countries – with industrial farming – have the majority of intellectual property rights or legal protection for new plant varieties or so-called improved varieties. This asymmetry with developing countries is due in part to the differences in access and research capacity with regard to new biotechnology for plant breeding. In EU countries, there are over 1 600 varieties of potato registered in the European catalogue and 16 481 plant variety protection (PVP) certificates have been deposited in the International Union for the Protection of New Varieties of Plants (UPOV). At global level, there are now 20 PVPs for new varieties of quinoa, of which 16 were obtained in Denmark and the Netherlands.

Introduced by the Spanish to Europe in the sixteenth century, potato went from being just a few tubers to becoming an essential food for countries in northern Europe in the eighteenth century. Unfortunately, mildew developed as a result of the monoculture of a small number of potato varieties. This situation led to the great famine of the nineteenth century (1846–1851), causing the loss of 25% of the Irish population in 10 years.

Even today, the strategies for disseminating new plant varieties or so-called improved varieties depend on a limited genetic base (to respect uniformity – one of the criteria required for a new PVP or for registration in a catalogue of plant varieties). This situation creates considerable risks related to potential diseases, epidemics and the spread of pests. These risks are exacerbated by the fact that all the improved varieties come from a small number of parent plants (as with potato when it was introduced and cultivated in Ireland).

In the twenty-first century, the agro-industry's continued research on the potato provides an insight into the growing dynamics of improvement and legal protection of new varieties relating to this sector. Similar dynamics are also likely to apply to quinoa in the short term. However, regardless of the intellectual property rights for genetic resources, discussion should be extended to the agricultural models to which the IPR apply: industrial farming versus family farming. This raises broad questions about genetic resources in relation to other criteria, such as identity, equity, *in situ* conservation and innovation for new plant varieties.

Those who promoted the 2013 declaration for the International Year of Quinoa, including FAO, expect to see a global expansion in the areas cultivated, with an immediate increase in demand for seed from other countries wishing to promote processes of genetic engineering and/or varietal improvement of quinoa. The IYQ keeps quinoa in the spotlight, making it possible to reflect on other alternative legal frameworks, without having to use the standard conventional framework for intellectual and industrial property rights. The case of quinoa provides insight into the case of a cross-border genetic resource, whose uses have recently extended beyond the agricultural and food sector. Until now, the legal framework of industrialized countries has dictated at international level, limiting the driving force behind alternative legal frameworks. Before the signing of the Convention for Biological Diversity (Rio de Janeiro, 1992), the global dissemination of genetic resources, in theory, made the CBD proposal ineffective in terms of a bilateral framework for the negotiation of genetic resources with sovereign states relating to the existing biodiversity on their territory. In this context, alternatives are required for cross-border links to assess whether regional and international levels of negotiation would facilitate or hinder the process in relation to the specific situations or issues at stake.

Quinoa: issues to consider that go beyond food and agriculture

The International Year of Quinoa: a new lease of life for global expansion

In July 2011, the United Nations General Assembly declared 2013 as the International Year of Quinoa following the proposal presented to FAO in Rome by the Plurinational State of Bolivia. The declaration brought recognition to the role that this plant can play in world food security. According to the FAO Resolution 15/2011, approved at the United Nations General Assembly in New York in December 2011, the declaration of the IYQ highlights the quality of quinoa as a natural food of high nutritional value and the importance of the role played by the Andean peoples in the creation and conservation of quinoa biodiversity. In addition, it emphasizes the importance of traditional knowledge and agricultural practices that respect and conserve nature.

On this basis, the declaration of the IYQ underlines the fact that, in 2013, world attention should focus on the role that quinoa's genetic diversity can play in terms of world food security and the eradication of extreme poverty and hunger, thus contributing to the Millennium Development Goals – MDGs (PROINPA, 2011).

At global level, the crop started to spread across all the continents in the 1980s, although two Andean countries, Bolivia and Peru are still the main quinoa producers (see Chapter 1.5) (Giuliani *et al*., 2012). In the 1980s, the United States of America introduced the crop first in the south of Colorado, and then in other states. Canada grows quinoa on the plains in Saskatchewan and Ontario. According to estimates, Canada and USA produce around 10% of the world's quinoa – that is probably more than Ecuador, which had until now been considered the world's third largest producer country.

In the 1990s, FAO-RLC (FAO Regional Office for Latin America and the Caribbean) defined one of its institutional priorities as: the exchange of plant genetic resources from diverse "underutilized" Andean food species that are considered suitable for production in different ecosystems in North America and Europe. In this context, the promotion, exchange and dissemination of quinoa's plant genetic material took the form of an experiment known as the American and European Test of Quinoa. Many countries from all over the world took part in the experiment through research networks that included national research institutes and universities (Mujica *et al*., 2001).

In Europe, quinoa is grown particularly in the United Kingdom, Sweden, Denmark, the Netherlands, Italy and France. In Asia, it is cultivated in the Himalayas, on the plains in north India and Pakistan where yields are promising. In Brazil, it is being grown experimentally as a cover crop in the Amazon Basin. In Africa, specifically in Kenya, it has also been grown experimentally for many years. More recently, it has been cultivated in Mali, where the plant has been introduced to reduce hunger and poverty.

With the quinoa boom in the 1990s and the impetus from FAO, the crop continues to expand, particularly in the Mediterranean region. Given the multiple exchanges and diverse uses of quinoa, the implementation of standards to regulate the movement of its genetic resources is complex, also because of the plant's tremendous ecological rusticity and plasticity (Ruiz *et al*., 2013).

A biodiverse plant with a great capacity to adap

Quinoa (*Chenopodium quinoa* Willd.), is an annual plant that originates from the Andes in South America. Its domestication is thought to have begun around 7 000 years ago with the continuous selection of the characteristics of individual plants from one generation to another. Selection criteria were linked to crop practices, as well as to organoleptic qualities for consumption among the diverse populations in distinct territories (Mujica, 2004). This broad process of selection and improvement from generation to generation led to a multitude of local varieties; dehiscence was suppressed and priority was given to increased seed size and adaptation to local environmental conditions (Bazile, Fuentes and Mujica, 2013; and see Chapter 1.4).

Despite the standardization process, with the loss of alleles during selection, even now cultivated quinoa exhibits a wide range of colours on different parts of the plant. The grains may differ in terms of stem type, panicle shape, rate of productivity, tolerance to abiotic stresses (drought, salinity) and disease resistance (Fuentes and Bhargava, 2011; Ruiz-Carrasco *et al*., 2011).

The diversity of quinoa on the South American continent is associated with five major ecotypes (Bazile, Fuentes and Mujica, 2013): Altiplano (Peru and Bolivia); Inter-Andean valleys (Peru, Ecuador, Colombia); Salare (Bolivia, Chile, Argentina); Yunga (Bolivia); and Coastal (Chile). All these ecotypes originate from the same region of primary domestication located near Lake Titicaca. In addition, eachone can be associated to a subcentre of diversity (Risi and Galwey, 1984; Fuentes, Bazile *et al*., 2012).

Many generations of farmers have been involved in this vast quinoa selection process, which explains its tremendous genetic diversity today. Its broad genetic diversity enables it to adapt to different ecological environments (highlands, valleys, mountains, salty zones etc.), different types of soil (in particular, saline soils), and places characterized by wide ranges in humidity (40 to 90%), altitude (0 to 4 800 masl) and temperature (-8° to +38°C). This capacity to adapt constitutes an advantage in today's context of climate change and salinization of agricultural land.

Quinoa's rusticity (its capacity to resist extreme biotic and abiotic stresses) and ecological plasticity are central to its potential in terms of developing cultivation in other parts of the world. These factors are even more relevant today, when measures to adapt to climate change must be promoted. Quinoa's great biodiversity means that it has capacities of adaptation and resistance and can, therefore, be grown in agri-ecological systems requiring lower levels of inputs. This coincides with the health requirements for its use in medicine, cosmetics and food. At present, quinoa is known primarily for its nutritional qualities, because it contains proteins (all the essential amino acids), minerals, vitamins, linoleic acid (omega-3) and amylases, and it is gluten-free. However, quinoa is also used in farming as an animal feed, as a cover crop or as an intercrop to stop the cycle of certain parasites. The uses of quinoa as a detergent, in cosmetics and medicine are less well known. Nonetheless, all its uses must be taken into account for the implementation of a legal framework to regulate movement and exchange of and access to quinoa's genetic resources on a global scale (see Chapters 3.4 and 3.5).

Agricultural systems with diverse legal frameworks

For a long time, Andean populations were in charge of quinoa production. In fact, when the Spaniards arrived, one way of making the Andean peoples submit was to impose a cereal-based diet. That is how quinoa was displaced and devalued, and its production confined to the Andean peasant communities. The Mapuche in southern Chile (Thomet *et al*., 2010) and the Andean communities in Peru are a good example.

Until recently, quinoa was considered food of the Andean peoples. It gained worldwide recognition in the 1970s, and was particularly appreciated by vegetarians for its dietary characteristics. For a long time it was classified as a subsistence crop, which explains why the Andean communities conserved a diverse range of traditional agricultural practices, because they could not combine them with a conventional agricultural model. This agri-ecological model is the most appropriate in a fragile environment subject to major abiotic constraints.

In Andean countries, most areas where quinoa is cultivated use traditional varieties, also known as peasant varieties or landraces. The Andean peasants focus on groups of varieties made up of heterogeneous plant populations. This means that they can cope strategically with different biotic and abiotic risks, by alternating individuals in a population (or landrace) on an annual basis. Seeds are home produced and the most resistant individuals are selected in the field for the next generation (seeds for the following year). This makes quinoa management dynamic and able to face risks and adapt to environmental, economic, social and political changes.

Traditional peasant management of the quinoa genetic resource pool contributes to the dynamic adaptation of quinoa varieties. These are the same varieties that have evolved continuously in relation to their ecosystems. Taking into account the characteristics of quinoa cultivation, the joint evolution of varieties and their environments can also include some results of crosses with quinoa's wild relatives growing near the cultivated plots. The networks of traditional seed exchange – seed paths – and the knowledge networks associated with the varieties have made it possible to build and maintain peasant innovation processes. This can now be seen in quinoa's huge genetic diversity (Aleman, 2009; Fuentes *et al*., 2012; Thomet *et al*., 2010).

The boom in global demand for quinoa in the 1990s led to the emergence of an intensive agricultural model and the use of only a few so-called improved varieties. Research on varieties shifted to the field of agronomic research (private and/or public) for the development of pure lines, hybrids etc., all of which had an increasingly narrow genetic base. Until then, the improvement of quinoa varieties had been based on three techniques: traditional massal selection, controlled crossing between genotypes and the development of commercial hybrids. The main objectives of the research in Andean countries were increased yields and improved disease resistance, gradually extending to include adaptation to the photoperiod (latitude), temperature and altitude found in countries outside the Andean zone.

Although various countries have signed international agreements, the transposition of these texts into national legislation differs from one country to another, depending on the agricultural policies implemented previously. Despite this, agricultural research remains public in Andean countries. Consequently, the new varieties obtained are not subject to intellectual property rights when they are released on the market. There is one exception: a case in Chile, where the quinoa variety 'Regalona', the fruit of private research (Semillas Baer), was protected by a PVP in order to protect the rights of the private breeder.

The current use of biotechnology in plant improvement via assisted selection, involving the use of molecular markers or genes of interest (resistance, chemical components, nutrients etc.), is in danger of modifying research and the legal frameworks for the regulation and protection of future quinoa varieties. The use of genes from wild quinoa relatives (for example, from *Chenopodium hircinum* or *C. album*) is considered the next step in creating new varieties that are part of strategies of adaptation to climate change (drought tolerance and soil salinity).

Over the last 40 years, different varieties of quinoa have been developed in Peru, Bolivia, Chile and Argentina, as well as in the United States of America, Brazil, Denmark, the United Kingdom, the Netherlands, and India etc. All these varieties come from the same initial pool of quinoa genetic resources linked to the domestication of the species in the Andes. They are "cross-border" resources, because the area of origin of the domesticated species covers several countries sharing these genetic resources. It is important to note that the movement of quinoa's genetic resources began long before the signing of the Convention on Biological Diversity (Rio, 1992). The CBD establishes principles and standards for the movement of genetic resources and, in general, recognizes that states have sovereignty over their biodiversity. The collections of quinoa germplasm are now spread throughout the world (see Chapters 1.4. and 1.5.). Even though the largest collections are in Andean countries (Bolivia, Peru, Argentina, Ecuador, Chile and Colombia), over 20 countries across the world conserve quinoa genetic resources in their ex situ genebanks. These include: South Africa, Germany, Australia, Austria, Brazil, Canada, Slovakia, Spain, United States of America, Ethiopia, Hungary, India, Japan, Kenya, Portugal, Czech Republic, United Kingdom, Sweden, Turkey and Uruguay. They share information with international systems such as FAO.

Since the Convention on Biological Diversity, more stringent legal frameworks have been created for access to genetic resources through bilateral contracts and material transfer agreements (MTA). The main objective is to guarantee the traceability of genetic resources and define the rights and responsibilities of each party in the exchange. Monitoring research on the adaptation of quinoa in different cropping contexts outside the Andes (e.g. ongoing improvement of varieties in future quinoa-producing countries) and seed multiplication raise numerous issues concerning systems for the management of genetic resources. Legal frameworks and regulations for the movement of quinoa's genetic resources need to recognize the role of the Andean peoples, who were involved in the varietal improvement long before these innovative processes. The objective is to avoid appropriation or limited access to quinoa's genetic resources, as was the case with the patent registered by the University of Colorado (subsequently abandoned due to international pressure). The patent was for the male sterility of quinoa discovered in the Andean quinoa populations conserved in the United States of America and known as 'Apelawa'.

The research to improve quinoa varieties has focused mainly in use of quinoa in food and agriculture. However, major research is underway on the by-products of quinoa as part of programmes to reduce cancer, obesity and diabetes or to find different ways of adding value to saponins etc.

Issues to consider for genetic resource management

DFor more than 500 years, varieties of potato have been part of food security strategies in many countries outside the Andes, the hub of its domestication. This is the result of the global dissemination of plant material domesticated and selected by the Andean peoples over thousands of years. The potatoexperience highlights the fact that the Andean peoples have received no benefits or significant recognition for having shared this improved plant material, which has since spread throughout the world. New species introduced into Andean countries do not offer comparative advantages to the local populations.

The current huge demand for quinoa has generated a boom in consumption, primarily in industrialized countries (some of which are new quinoa producers). This situation has brought changes to the agricultural systems in the Andes. In contrast to what happened a few centuries ago with the potato, the Andean populations are now active stakeholders in defending the recognition of their contributions to the improvement of quinoa varieties and the conservation of its genetic resources. They also want to be recognized stakeholders in world trade.

International treaties recognize the sovereignty of states with regard to their genetic resources and the contribution made by indigenous communities to their conservation. They set out the principles to promote the fair and equitable sharing of the benefits derived from the utilization of these genetic resources, which are available to all the countries in the world. At present, those seeking to spread quinoa cultivation are supporting experimental agronomic campaigns in many countries outside the Andean zone. It is, therefore, of the utmost importance to analyse how dissemination programmes can ensure a return (fair and equitable sharing of the use of quinoa's genetic resources) for the Andean communities and states as laid down in international agreements (CBD/Nagoya, ITPGRFA). This also includes an analysis of the systems of intellectual property rights in force (patents, PVP certificates).

The UN declaration of 2013 as the International Year of Quinoa emphasizes the role of the Andean peoples in creating and conserving the biodiversity of quinoa. In this context, considering the current global boom in quinoa, several issues are raised: Will promotion simultaneously guarantee the Andean peoples the fair and equitable sharing of the benefits derived from the use of quinoa's genetic

Table 1: Characterization of the issues related to plant genetic resource management

Identity	Recognize the traditional ways of life of interest for the conservation of biodiversity and the sustainable utilization of its genetic resources. Respect, conserve and maintain the knowledge, innovations and practices of indigenous and local communities.
Conservation	*Ex situ* conservation: conservation of the elements that constitute biological diversity outside their natural environment. *In situ* conservation: conservation of the ecosystems and natural habitats, maintenance and reconstitution of viable populations of the species in their natural environment and, in the case of domesticated and cultivated species, in the environment where their distinct characteristics were developed.
Mobilization Sustainable utilization	Facilitate the exchange of genetic resources. Encourage different forms of innovation and synergy between formal and traditional systems for utilization and adding value to genetic resources. Encourage an evolutionary dynamic for genetic resources to increase the capacities of adaptation to cope with global changes (resilience).
Equity	Draw up equitable rules for access to genetic resources. Draw up equitable conditions for sharing the benefits derived from the utilization of genetic resources at stakeholder and country level. Increase the capacities for exchanging information and accessing technology for the equitable utilization of genetic resources between countries and stakeholders with different capacities.

resources? How should quinoa's genetic resources be conserved *in situ* and *ex situ* to avoid their genetic erosion? What mechanisms should be set up for the fair and equitable exchange of quinoa's genetic resources? How can such exchanges contribute to the recognition of the Andean populations and to the processes of conservation used by them for quinoa's genetic resources? To what extent exisitng regulatory frameworks make it possible to enrich quinoa's genetic heritage?

Many different issues are at stake with regard to the legal frameworks regulating the movement of quinoa's genetic resources. The existing regulatory frameworks should be examined to determine how they contribute to quinoa's genetic resources in terms of: conservation (i*n/ex situ*), the identity of the Andean communities (cultural recognition) and the potential mobilization of the resources (exchange, innovation, formal/informal). Table 1 outlines a proposal for characterizing the different issues and serves as a guide throughout this chapter for analysing the advantages and disadvantages of the legal regulatory frameworks currently in effect and assessing which other regulatory frameworks could be outlined to bridge the gaps in the existing ones.

Are the legal frameworks adapted to the diverse aspects of quinoa's genetic resource management?

In the light of global concern about the depletion of biological diversity resulting from human activity, an international regime composed of several instruments was set up to guarantee the sustainable utilization and management of biological resources.

Genetic resources, which are biological resources, are genetic material of real or potential value to humanity. The majority of agricultural genetic resources, including quinoa's genetic resources, are mainly regulated by the CBD and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA/FAO 2001, http://www.planttreaty.org/). ITPGRFA governs the genetic resources of the main food crops, listed in its Appendix 1.

The principles of fair and equitable benefit-sharing proposed by the CBD

LThe Convention on Biological Diversity (CBD) adopted within the framework of the 1992 Earth Summit in Rio de Janeiro (http://www.cbd.int/) recognizes the sovereignty of states and acknowledges that states are responsible for the conservation of their biological diversity and for the sustainable utilization of their biological resources. Consequently, states should establish national strategies for the conservation of their biological diversity, and provide a framework for bilateral arrangments relating to their biological resources.

The practices involved in accessing and exchanging genetic resources are regulated via private law agreements on sharing the benefits derived from contractual bilateral agreements between a provider and a recipient.

This solution is based on Coase's theory of externalities (Coase, 1974): the market does not confer a value on diversity for individuals and society, so in parallel, no person can be easily excluded from its use (consequently there is no incentive for an individual to pay the costs of access to this diversity). Therefore, a negotiation between private parties, via the establishment of a contract granting property rights for genetic material, is considered an effective method for reflecting the value of genetic diversity. In addition, direct or indirect monetary incentives are established, linked to the sharing of benefits derived from the use of the genetic diversity.

Nonetheless, there is still considerable uncertainty surrounding the value of the material at the time of access to genetic resources, as well as a lack of legal security in the event of non-compliance by one of the parties. As a consequence, these contracts are embedded within national legislation and are part of a wider range of legal mechanisms or agreements seeking to limit opportunistic behaviour (Dedeurwaerdere, 2004). These mechanisms include, *inter alia*, standard contracts, mechanisms to monitor and enforce contractual obligations (e.g. disclosure of origin of genetic resources or certification of origin) and prior informed consent of the indigenous local populations.

Nonetheless, even when part of national legislation, the contractual approach for regulating access to genetic resources and sharing the benefits of their use is not sufficient to achieve broader related societal objectives such as social equity and conservation and sustainable use (Dedeurwaerdere, 2004; Goëschl and Swanson, 2002). In effect, the combination of (hierarchical) public regulations and monetary incentives applied in these contracts fails to account for the diversity and complexity of the stakeholders' actual motivations in exchanging genetic resources. These regulations do not properly reflect the needs of the wide range of actors involved in the use and exchange of genetic resources. In fact, they are only efficient for the category of users and uses that are most responsive to monetary incentives. The exchange of genetic resources actually responds to a more complex set of motivations, including societal motivation (global public objectives, such as increasing knowledge, conserving biodiversity or reducing hunger) and more basic social motivation (such as reputation, reciprocity). In fact, stakeholders' surveys (Dedeurwaerdere *et al.*, 2012) tend to demonstrate that striving for notoriety (by virtue of material quality, information exchanged or publications) and/or reciprocity (exchange of information between stakeholders) are among the principle motives for the conservation and exchange of genetic resources.

Furthermore, even supposing that economic incentives work properly, they will never allow for sufficient investment to maintain and exchange genetic resources, because the value of most of these resources is and will remain unknown for years.

Lastly, in certain cases, using monetary incentives for all types of exchange of genetic resources can be counterproductive. The introduction of market values can be a disincentive for contributing to the collective effort to conserve the genetic resources within local communities. Introducing monetary-based approaches where it does not exist could generate mistrust and suspicion ("crowding-out" effect, described by Frey and Jegen, 2001). In other words, the emergence of a contract can undermine the cooperative or collective practices required for genetic resource conservation.

Clearly, these problems seem to be even more acute in the case of plant genetic resources for food and agriculture, including quinoa genetic resources. Going back to the identity dimension of our analytical framework, Article 8j of the CBD explicitly covers this dimension, recognizing *knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity*. Nonetheless, in the CBD, the question of to exactly what extent this would be applied is left to the responsibility of the states. In the case of quinoa, the question of local identity is linked to the Aymara, Quechua and Mapuche cultures but development policies ultimately depend on the national perspective, which may or may not recognize these local groups in genetic resource management. (It may also lead to other broader debates not directly related to genetic resource management. In such context, it would inevitably be difficult to implement the CBD.

With regard to conservation, the CBD applies to all genetic resources, without exception. The specificities of agricultural genetic resources/plant genetic resources useful for food and agriculture were not taken into account. One of the main criticisms of the CBD (and the Nagoya Protocol) is that the mechanisms for access and fair and equitable sharing of benefits derived from the use of genetic resources are loosely linked to conservation. This should be factored into national strategies. Nonetheless, the situation for plant genetic resources for food and agriculture often appears to be secondary in national strategies, especially in the case of genetic resources from wild biodiversity (crop wild relatives).

The challenges relating to innovation (derived from?) genetic resources make the implementation of national strategies even more difficult. However, the CBD framework ensures full control of access to quinoa's genetic resources. Furthermore, it could be consolidated by the implementation of national strategies, with the support of national authorities responsible for access to and traceability of genetic resources. In this context, the rights and responsibilities of the parties are more explicit. Conversely, in the context of bilateral contractual relationships between states, the supplier country could easily block access to its genetic resources and effectively prohibit all possibility of innovation. In the case of research processes to improve and obtain new plant varieties, the exchange of genetic resources is and should be recurrent. Consequently, bilateral contractual frameworks for access to these genetic resources can be cumbersome, in addition to generating high transaction costs.

The incremental nature of the innovation process on genetic resources for food and agriculture makes it particularly difficult to adopt a bilateral and case-by-case approach, in terms of both access and sharing the benefits derived from the use of genetic resources (Schloen et al., 2011). Besides, in the case of quinoa, its genetic resources were circulating between stakeholders and countries long before any ABS measures were in place. There are currently collections of genetic resources of quinoa in different places in the world. From a strictly legal point of view, the exchange processes for these genetic resources (obtained before the CBD, 1992) could be conducted legally, without involving the countries of origin (the zones where quinoa was domesticated) in the exchange.

Furthermore, a relatively high number of products (not necessarily all marketable) can be derived from the utilization of plant genetic resources for food and agriculture. Many of these could be elaborated or developed from multiple genetic resources. Each genetic resource, taken individually, can contribute to the final product at different levels and at different points in time. The task of monitoring the separate contribution of each genetic resource and determining the benefits to be shared in relation to its individual contribution, on the basis of the terms and conditions specified in a bilateral contract for each genetic resource, could prove to be extremely complicated (Schloen *et al.*, 2011).

Despite the different limits identified, the legal framework established by the CBD is now compulsory for processes involving the prospection and collection of new genetic resources of quinoa. This limits the potential cases of biopiracy associated with the collection of new genetic material for agricultural, pharmaceutical, medical and cosmetic purposes under development for quinoa. Nonetheless, this legal framework is ineffective when genetic material is accessed from germplasm collections located outside Andean countries.

The legal framework for intellectual property rights (WIPO–WTO)

- Patents (TRIPS) versus PVP (UPOV)

The legal framework for intellectual property rights (IPR) for living organisms is based on financial incentives that aim to encourage biological innovations. By providing legal protection mechanisms for inventions based on genetic diversity, intellectual property should encourage the use of quinoa's genetic resources. As mentioned in relation to the different concepts relating to the status of genetic resources, the agricultural sector is characterized by the coexistence of at least two intellectual property systems: patents and plant variety protection (PVP). Both systems are promoted at international level by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) of the World Trade Organization (WTO) and by the International Union for the Protection of New Varieties of Plants (UPOV). The latter advocates a *sui generis* system adapted to the self-reproductive and evolutionary nature of plant genetic material. A product derived from innovation, i.e. a new plant variety, is a genetic resource in itself. A balance must be found between protecting innovation and limiting access to genetic resources. This balance is central to the UPOV and does exist in the form of exemption for research. Thus, the genetic resources of a new plant variety protected by plant variety protection (PVP) can legally be used for research purposes.

The UPOV system also provides better legal security than the patent system: a product can have numerous patents, while a new plant variety is protected by a single PVP (Dutfield, 2011). There are far more disputes in the patent system than in the PVP system, and "patent thickets" arise – intricate problems of patents dependent on other patents (Shapiro, 2000; Heller and Eisenberg, 1998), monopolization of patents or inadvertent violations of patents.

In general, with the exception of a limited number of countries (including the United States of America), the patent system is not used to protect new plant varieties directly. It is used to protect biotechnological inventions, such as genetic sequencing or procedures that constitute the basis of plant breeding. Irrespective of the technical differences between the two systems, the intellectual property system for genetic resources reveals fundamental problems that have been and are the subject of debate in numerous publications. One of the main criticisms directly related to the problem of the conservation and use of genetic resources is, in fact, that intellectual property rights only intervene at the very end of the genetic resource value chain. Consequently, they only function effectively as an incentive mechanism for new plant varieties or plant material for which the value is already known (even partially) either from available data on characterization or assessment. Thus, intellectual property rights provide far too few incentives for the exchange of most components of genetic diversity found *ex situ* (even less for those *in situ*, where the value of genetic diversity is still unknown at the time of its accession) (Swanson and Goëschl, 2000; Goëschl and Swanson, 2002).

In addition, intellectual property rights are not an effective incentive for innovation and research – either in cases of low demand, or for countries lagging behind in the scientific advances of cutting edge innovation. Such countries are unable to benefit from the advantages of legal protection provided by intellectual property rights. Lastly, as with the effects of exclusion (crowding-out), described earlier for access and benefit-sharing mechanisms, the introduction of economic incentives can negatively impact the exchange of genetic material or information during pre-competitive phases. These situations – "anticommons" – can negatively impact cooperative and altruistic behaviour (Heller and Eisenberg, 1998; Cassier, 2002). All these problems are exacerbated in the agricultural sector, as agricultural innovation is about coordinating research between many different stakeholders rather than a question of individual incentives.

If the private seed sector manages to function well thanks to individual incentives, it should be noted that the private sector depends directly and indirectly on public research institutions and their studies of genetic diversity. In the public sector, financial incentives do exist, but they by no means represent all the existing motivation factors behind the exchange and use of genetic diversity. Similarly, those who defend local community rights or rights relating to the traditional knowledge associated with biological diversity, recognize, first and foremost, the existence of collective rights that govern access, exchange and use of seeds and genetic resources. They are not restricted to a framework of individual rights, as in the case of intellectual property rights.

- Geographical indications and collective trademarks

Geographical indications and collective trademarks are also part of a system of intellectual protection or, more specifically, industrial protection.

In the agricultural sector, *in situ* exploration, for both biological material and local knowledge associated with biodiversity resources, generally serves the purpose of enhancing *ex situ* collections (defining the characteristics and legal status of the plants collected). It should therefore be asked what role geographical indications can play (e.g. protected geographical indications or designations of origin) to promote the conservation of genetic resources, or maintain and protect local knowledge. Geographical indications denote that a product originates from its place of production. In the case of plant selection, this makes it possible to add value to a variety, not only in relation to its geographical origin but also its genetic identity. For example, the aim of a plant variety protection (uniform, distinct and stable variety, close to varieties from pure lines) is to obtain a phenotype independent of local ecological conditions.

Geographical indications reveal the characteristics of a product. These are determined by the specificities present when the geographical indication is developed and include: geology, soil, topography, climate and human factors (current techniques and/or traditional knowledge). A geographical indication can also refer to cropping practices or processing practices that affect the quality of the product and contribute to its distinguishing features and reputation. Consequently, there is a link between the product and the geographical environment, making it possible to distinguish the product from those originating from other regions.

Geographical indications are also part of the TRIPS of the WTO. Each member state is free to define appropriate mechanisms for implementation within the national legislation. Some countries, such as the United States of America and South Africa, have not adopted national standards for the protection of geographical indications, but use other mechanisms, including consumer protection, trademarks or fraud control (passing off) (Kalinda, 2010).

Geographical indications are used for products of specific geographical origin, with qualities and/or a reputation derived from that place of origin. In general, a geographical indication states the name of the product's place of origin. Geographical indications include the "appellation of origin". This is a special type of geographical indication used for products with specific qualities that must be exclusively or essentially from the product's geographical context of production or processing. The regulation of geographical indications for processing products must be approved and should also be subject to control by nationally accredited organizations. For example, in Bolivia, the designation of origin "Quinoa Real" from the southern altiplano of Bolivia has existed since 2002 and was also recognized in the administrative resolution N°18 (on 23/07/2002) of the governmental intellectual property organization (SENAPI).

The Lisbon Agreement for the Protection of Appellations of Origin and their International Registration made it possible to obtain protection for an appellation of origin specified in all the contracting parts of the agreement, following a single international registration procedure. Currently, 28 countries are party to the Lisbon Agreement, and Peru is at present the only country from the Andean region. At regional level in Latin America, the Andean Community (CAN) also protects appellations of origin in its member countries via the Common Intellectual Property Regime outlined in Decision 489 – CAN.

The duration and cost of protection vary from one country to another, and it is often necessary to obtain the geographical indication in the country of origin. This hinders innovation aimed at improving product quality; changes in the regulations could lead to an improvement in practices and quality.

A trademark is a distinctive symbol enabling consumers to distinguish the geographical origin or characteristics of a product.

A collective trademark belongs to an association. Its members – companies, producers, public institutions or cooperatives – define rules to guarantee that the product meets certain quality requirements or has specific characteristics (WTIP, 2013).

A collective trademark should be protected independently in each country or group of countries seeking protection (e.g. Peru or the EU, where common protection exists). A trademark encourages stakeholders to innovate in order to improve product quality and represents progress. A trademark is more dynamic than a geographical indication. It ensures more effective value added for products, as it recognizes the specificities that add value to these products. Nonetheless, trademarks do not protect genetic resources.

Today, no intellectual property rights protect genetic resources and guarantee the fair and equitable sharing of benefits derived from their use. What is more, high costs are entailed both in registering intellectual property rights and in maintaining rights over time.

- National or regional catalogues

In France at present, for a plant variety to be authorized and put on the market, it must be registered in a catalogue of varieties and satisfy criteria of distinctness, uniformity and stability (DUS). It must also demonstrate that it has an adequate value for cultivation and use (VCU). The new variety must exceed commercially available varieties for certain criteria. The DUS criteria are the same as those for PVP and are an intellectual property right for seeds.

In West Africa (including Mali), a catalogue of plant varieties exists, comprising also newly obtained plants and local varieties (populations). In many countries, registering a variety in the catalogue is not a precondition for selling and/or using the seed (including in the United States of America).

Finally, if a country decides that to commercialize and/or use a variety, it may be registered in a national catalogue. But, once registrered in such catalogue this does not mean that it automatically qualifies for DUS/VCU as a prerequisite for registration. Some catalogues (e.g. in West Africa) have adopted less stringent requirements that in DUS/VCU.

Assuming that a harvest can be sold – i.e. that a market exists – a new variety can be registered in a specific catalogue (catalogue for the conservation of varieties in the European Union) of conservation varieties, i.e. primitive races and agricultural varieties naturally adapted to local and regional conditions or threatened by genetic erosion. This catalogue was created with the aim of conserving local and traditional varieties (genetic resources and associated knowledge) in view of their genetic resource heritage.This catalogue limits varietal improvement a priori (improvement goes against conservation), unless the new plant variety satisfies the DUS and VCU requirements for registration in the "official catalogue of plant species and varieties." In this case, France has a particularly strict legal framework.

In conclusion, the analysis of the framework for intellectual property rights and of the application of intellectual property for innovation (especially for new plant varieties), highlights the asymmetry between countries in terms of their research capacities and access to global research results. The ongoing development of new quinoa varieties depends on access to and management of cutting edge biotechnologies used to obtain new plant varieties. However, a country which has access to the scientific capacity for obtaining new varieties also has the financial means to protect varietal innovations. The cost of a PVP or patent application is a constraint for some countries.

Finally, intellectual property rights in relation to genetic resources go beyond the legal framework of seed production for agriculture, because new uses in medicine and cosmetics are being developed. Thus, DUS should be considered not only in terms of the characterization of functions, but also for the resulting transformations (UPOV 91, TRIPS patents).

Can FAO's The Treaty address all the situations arising linked to quinoa

Sustainable use and conservation of plant genetic resources for food and agriculture are a common concern for countries across the world. This is because all countries depend primarily on the exchange of plant genetic resources from other areas. Concern about the continuous depletion of these resources calls for specific measures that take into account the special nature of these resources.

The development of The Treaty is a direct response to this call for a specific solution. In harmony with the CBD, it aims to achieve the conservation and sustainable use of plant genetic resources and the fair and equitable sharing of the benefits derived from their utilization for sustainable agriculture and food security. While these objectives apply to all plant genetic resources for food and agriculture, the principal tool –the Multilateral System for Access and Benefit-Sharing (MLS) – only applies to a list of cultivated species registered in Annex 1 of ITPGRFA and in which quinoa is not to date included.

ITPGRFA as a pluralistic legal framework

Given the limitations of the CBD's legal framework for access and benefit-sharing, the sector of plant genetic resources for food and agriculture (PGRFA) developed alternative mechanisms that are better adapted to the specific nature of PGRFA and the way they are used in research and development.

Considering the various aspects of PGRFA (diversity created by man, importance of diversity intraspecies for improvement, greater interdependence between countries, constant need for new varieties, importance of food security etc.), a collective management mechanism has been designed to enable access to these resources and to ensure the fair and equitable sharing of benefits derived from their use. The MLS indeed pools at global level genetic material coming from contracting parties (i.e. state governments), international and regional institutions, and natural and legal persons. They all agreed on the same contractual obligations for any transfer of material coming from the MLS: the Standard Material Transfer Agreement (SMTA). The objective of the standardized access and benefit-sharing provisions is to reduce transaction costs that would occur if access and benefit-sharing were subject to bilateral negotiations rather than to a multilaterally agreed standard agreement. The system also reduces the costs of redistribution by dissociating distribution of benefits from individual supplier countries. It also highlights the non-monetary aspects of the benefits generated, which are often expressed independently of the fact that a product may or may not be on the market.

The Treaty adopts a "global commons" approach rather than a bilateral approach (Halewood et al., 2012). This international collective approach is nevertheless compatible with a vision of genetic resources as private goods. Genetic resources conserved privately are free to be included in the Multilateral System and the private appropriation of plant genetic resources from the MLS is still possible (via a patent), although sanctioned by a fee. The fee is designed to sanction the breaking of the facilitated access logic agreed collectively within the MLS. The fees are allocated to a general global fund for the benefit of all signatory parties.

The Treaty is far from limited to the Multilateral System. Other provisions are equally important in the context of this paper. Article 9 deals with farmers' rights. It recognizes past and present contributions of local communities and farmers to improve and conserve plant genetic resources, and it encourages the protection of traditional knowledge relevant to plant genetic resources for food and agriculture. However, implementation is limited by the fact that it remains the responsibility of states to implement this provision. While limited in practice, the proclamation of farmers' rights does acknowledge the legitimacy of the existence of a form of management in which plant genetic resources are not considered to be a private good or a public good (national or international), rather a common good shared by farmers of the world.

The effective implementation of this right generates problems and, despite some local initiatives, there is little support from states (Andersen, 2008). However, the Treaty is currently the only treaty that proposes a pluralistic legal framework, recognizing the legitimacy (despite the immense difficulties involved in its effective implementation) of the different concepts involved in relation to the status and management of genetic resources.

However, the fragile balance achieved by the Treaty remains imperfect. The treaty's various components are being implemented by countries at different rates, and there is a perception of inequity for some signatory parties. If facilitated access to genetic resources (promoted by the Treaty) is crucial for the agricultural and food sector, one of the main inequities perceived is that not all countries can benefit in the same way from facilitated access to PGRFA. Whether it is justifiable or not, greater and exclusive emphasis on ex situ conservation is perceived by many to mainly serve the interests of industrialized countries and of stakeholders that are more developed in terms of biotechnology. This situation is exacerbated by the fact that the effective use of plant genetic resources obtained from the MLS for commercial purposes only requires minimal monetary compensation, which – depending on the type of protection applied to the innovation – may even be voluntary. The voluntary and compulsory compensation payments are allocated to an international fund.

Advantages and limitations of including quinoa in Annex 1 of the Treaty

The species *Chenopodium quinua* is currently absent from Annex 1 of the Treaty. Proposing its inclusion in the list is no easy task, partly because of its specific characteristics, which are linked to its original geographical distribution, the current distribution of its genetic resources, its different uses etc. Therefore, an in-depth analysis of the advantages and disadvantages of its inclusion would help identify the various situations arising. Perception varies, depending on the specific interests of the different stakeholder groups in relation to the species' genetic resources.

Advantages:

- Quinoa collections are spread in different countries throughout the world and international exchanges occur largely outside the Andean countries. The MLS may be a way to recover some kind of control on quinoa's genetic resources for which they de facto lost control on.
- Such an international legal framework makes biopiracy more difficult or at least more risky. Including quinoa in the Treaty's MLS could be an efficient defensive measure to avoid the misappropriation of genetic resources.
- The Treaty allows the benefit-sharing fund to be open to developing projects to characterize phenotypes, or to participative breeding programmes for quinoa varieties (participatory plant breeding – PPB). Projects developed at regional or global level may yield collective benefits and generate new sources of financing.

Limits:

- Despite the undeniable advantages of the Treaty, it does have certain limits and cannot respond to all the situations that arise with regard to quinoa's genetic resources. This is largely due to the fact that quinoa is a species with multiple uses. Little is known about the exchange of quinoa's genetic resources for non-agricultural and non-food purposes (e.g. pharmaceutical and/or cosmetic). These activities are not regulated under The Treaty.
- Quinoa's countries of origin may have difficulty understanding and, consequently, agreeing with the implementation of the Treaty. For this reason, they are opposed to quinoa's inclusion in Annex 1, especially considering the small amounts of money available in the benefit-sharing fund. Focusing on the financial dimension – rather than on the non-monetary compensation or advantages and the benefits derived from respecting the Treaty requirements – is somehow contradictory from a practical point of view. However, it is a strong political argument undermining the treaty.
- The loose interest in the implementation of Article 6 (sustainable use of genetic resources) and Article 9 (farmers' rights) of the Treaty, which are particularly adapted and relevant for promoting the sustainable use of quinoa, may be a source of frustration for some stakeholders. Although not directly related to the MLS, the lack of progress in these areas means less support for the inclusion of quinoa in Annex 1. Obviously, the Treaty is still a relatively new instrument, and further developments are still to come. However, these articles do not have the same operational character and power as Articles 10–13 concerning the MLS.
- The MLS is particularly adapted for genetic material conserved ex situ in national or international seed banks; it is less adapted for the exchange of material conserved in situ and for genetic material developed in plant breeding centres.
- Regardless of the Treaty's operational dimension, unless there is a major and drastic change in the treaty, the challenges posed by strong intellectual property rights will remain outside the scope of the treaty and will need to be addressed by other international legal texts.

In conclusion, two main issues are fundamental to the inclusion of quinoa in the MLS: the recognition of quinoa as a cultivated species, as well as its wild relatives, and their role in its evolutionary dynamics; and the industrial use (for medicinal and/or cosmetic purposes) of quinoa.

Although The Treaty proposes a more pluralistic and better adapted framework than the CBD, it does not address all the challenges in relation to the management of quinoa's genetic resources. Important issues for quinoa's countries of origin – e.g. recognition of the Andean communities and sharing the benefits derived from the utilization of quinoa – remain to be properly addressed.

Other alternatives

Following this preliminary analysis of the existing legal frameworks, the question of "inaction" must also be raised in order to compare this analysis with the case of potato and its genetic resources (for example, to date, neither Bolivia nor Ecuador, both UPOV member countries, have any PVPs).

Various aspects of genetic resource management have been taken into account in the legal frameworks provided by the CBD, the Treaty, the TRIPS and UPOV conventions. Nevertheless, this context raises questions: can the current legal frameworks be improved or can their implementation effectively take into account the diverse situations not addressed until now? If not, which alternative legal frameworks would deal with these situations better?

Improving the current legal frameworks

- The Convention on Biological Diversity CBD

As previously mentioned, the CBD provides a global legal framework (in terms of application). The recently adopted Nagoya Protocol provides a precise legal framework capable of responding to some of the challenges identified concerning quinoa's genetic resources. The modalities of exchange and innovation, and the importance of ex situ collections, mean that this legal framework is not sufficiently adapted for its current application.

Articles 10 and 11 of the Nagoya Protocol outline potential changes that could be of interest in the case of quinoa. Article 10 concerns cases where the sovereignty of genetic resources is unclear or difficult to deal with. It obliges the parties to examine the need for and the modalities of a global multilateral benefit-sharing mechanism to ensure the fair and equitable sharing of the benefits derived from the use of genetic resources and the associated traditional knowledge. It applies to cross-border situations or cases in which it is not possible to reach an agreement or obtain prior informed consent. In such situations, member states should examine the need for and the modalities of a global multilateral benefit-sharing mechanism.

A multilateral mechanism could help avoid the excessive costs of monitoring and traceability, and its scope could be either broad or narrow. A broad interpretation addresses the question of the temporal or geographical scope of the Nagoya Protocol (Dedeurwaerdere *et al*., 2012). In a narrow interpretation, the multilateral mechanism covers the genetic resources of the centres of origin and those of unknown status, and even encompasses genetic resources in ex situ collections in place before the CBD came into force (Buck and Hamilton, 2011).

As with The Treaty, it is important to highlight that, in accordance with the multilateral mechanism, the benefits to be shared should be used to promote and implement processes geared to the conservation of biological diversity and the sustainable use of its component parts on a global scale. This means that benefits are not shared with the supplier country or countries, a situation that may prevent some countries from adopting this type of mechanism.

Article 11 envisages collaboration when the same genetic resources are located *in situ* in the territory of more than one member country. Unfortunately, as in the case of Article 10, the language is vague and poorly defined. There is no precise definition for "similar genetic resources". In the framework of common scientific research projects, the case of the same genetic resource from two countries would only occur in the case of plants (characterized by high genetic stability), and not microbial strains (most strains of the same species are not exactly the same or the slight genetic differences generate different properties because of the relatively small size of a microbe's genome) or animals (different individuals of a race). Consequently, the article probably has a very limited field of application in relation to agreements on access for research purposes.

In addition, questions relating to benefit-sharing in cross-border situations remain unanswered. If the same rule applies as in Article 10, it may not be considered worthwhile applying it in the case of quinoa.

- The Treaty, Articles 6 and 9

The Treaty member countries are faced with the challenge of successfully promoting the sustainable use of PGRFA. This involves equitable policies for maintenance of agro-ecosystem diversity, agro-ecological research, maintenance of a broad genetic base, participative plant breeding, and promotion of underused crops to reduce genetic erosion and increase food production at global level.

The responsibility of member countries is emphasized: to protect and promote farmers' rights via the sharing of benefits derived from the use of PGRFA, protect traditional knowledge linked to PGRFA, participate in the adoption of decisions on conservation and the sustainable use of PGRFA, and guarantee farmers the right to exchange and sell their varieties.

One of the key elements of The Treaty is the sustainable use of plant genetic resources, as specified in Article 6. This article applies to all plant genetic resources and not only those from the species listed in Annex 1. However, all the the Treaty signatory parties pledge to implement the provisions required to achieve these objectives, without delegating the responsibility solely to the states, as in the case of Article 9, "Farmers' Rights", or Article 5.1, "Conservation".

Article 6 resumes *de facto* the key topics described in the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, adopted at the 1996 Leipzig Conference.

These specificities on the sustainable utilization of plant genetic resources should make it easier to implement in those states party to the agreement – in contrast to Article 9 on farmers' rights, which is generally a subject of major debate in negotiations, at both national and international levels.

However, in practice, Articles 6 and 9 are frequently associated with paragraph 9.3, related to the rights that farmers have to save, use, exchange and sell farm-saved seed/propagating material, subject to national law. This article clearly follows on from paragraph 6.2, which promotes the maintenance of agricultural systems that conserve diversified genetic resources in a sustainable way. The analysis of the objectives of Articles 6 and 9 emphasizes the need for discussion to review and adapt the standards for the diffusion of varieties and selection strategies, while leaving room for a participative breeding framework.

It is also necessary to examine the protection of traditional knowledge linked to the promotion of the use of local varieties and underutilized species. The benefit-sharing measures are general, and their application depends on the definition adopted for the fair and equitable sharing of the benefits derived from their utilization. A purely commercial approach based on economic interests creates the risk of introducing subsidy mechanisms for the conservation of local varieties. Consequently, fair and equitable benefit-sharing should investigate mechanisms of implementation that promote the non-economic benefits of the sustainable utilization of agricultural biodiversity. In this way, farmers' access to genetic resources could be facilitated and extended. In addition, processes could be implemented to support farmers to exchange and mutually enrich their strategies for breeding/varietal creation, taking into account, above all, their needs and their participation in the innovation process. In this context, the diverse existing legal frameworks (CBD, ITPGRFA, UPOV, TRIPS, regional and national legislation), as well as participative breeding processes, could serve as a basis for reflection at global level.

- Recognition of traditional varieties apart from PVPs and patents

In this analysis, it is important to underline the case of the EU, particularly France, where intellectual property rights are not necessarily linked to an authorization for marketing, but rather to the right to prohibit. Likewise, the case may arise when a variety is authorized to be put on the market but may not be protected by intellectual property rights. Consequently, if intellectual property rights are applied on their own, it is not possible to control all the issues relative to the management of genetic resources and the seed sector. In this case, "complementary" rights should be assessed, for example, the right to introduce a variety on the market with a single authorization. Analysing these aspects is important and particularly useful for understanding the utilization, exchange and, above all, sale of traditional and local seeds (most of which do not comply with DUS criteria and do not have a sufficiently high VCU).

In France and in the majority of EU countries, a seed from a plant variety that is not registered in the official catalogue cannot be sold or exchanged. However, it is possible to sell the harvest derived from the utilization of varieties of seeds not registered in the national catalogue. Varieties for conservation are exempt because they have their own catalogue, although their uses are limited (see previous point). What would be the consequences if a similar system became more widespread? What would the risks be for farmers who only use their own seeds from traditional varieties (with no exchange and no marketing) or who become dependent on national or transnational seed companies?

At national or regional level, should a legal framework be defined for licences to market agricultural inputs, including seeds? In this legal framework, what should the criteria be for authorization or prohibition? The objective is to develop licensing strategies as a function of the varieties actually utilized in countries and which are adapted to the varieties developed in the country. This means that all the stakeholders involved (interested parties) should contribute to the development of these strategies (both farmer breeders and seed and processing companies). In this legal framework, the case of biopesticides in Europe is enlightening: in terms of the criteria of homologation, biopesticides are less effective than their chemical substitutes. Consequently, they are authorized as supplements. This decision may be considered "not fully satisfactory" yet it provides authorization.

It should not be permitted to consider traditional varieties as supplementary in relation to a set standard for the new plant varieties registered in the catalogue. It undermines the perception of local and traditional varieties obtained by farmers and/or their organizations.

Various negotiations are underway at CBD and WIPO–WTO level in relation to the use of traditional varieties in breeding programmes in order to: guarantee the traceability of exchanges of biological material; and implement the certification of origin and a process of disclosure of origin for biological material at the time of application for intellectual property rights and, particularly, at the time of application for patents. However, the application of these certificates in the seed sector could be complicated because there are multiple crosses, which means that transaction costs would grow exponentially. The alternative is to recognize the knowledge that farmers have of traditional and other varieties, as suggested in the previous section within the framework of the Nagoya Protocol and IPGRFA.

The different options available to countries for the management of the relationship between traditional seeds and seeds from new plant varieties include: defining the licences for market sale; and defining the conditions of seed utilization and exchange. However, the choice of these different types of licensing will have an impact on agricultural production in the country in question and on the possible methods of selection and development of new plant varieties. The interests at stake in relation to licensing for market sale and certification, therefore, concern numerous materials and multiple uses. Following the EU example, there are at least seven types of seeds: protected varieties registered in the catalogue; varieties registered in the catalogue that are not protected; old varieties no longer registered in the catalogue; traditional varieties registered in the catalogue of conservation varieties; traditional varieties not registered in the catalogue of conservation varieties; seeds from protected farm varieties; and seeds from farm varieties that are not protected and are registered in the catalogue.

For each of these varietal types, there are many possible options that are mutually inclusive in terms of access and utilization:

Can they be marketed? Is registration in the catalogue required or not? Who can market them? In France, for example, only the owners or suppliers of varieties registered in the catalogue can market them. A farmer cannot sell any variety that he has improved if it is not registered in the catalogue.

What are the conditions to ensure seed exchange between farmers? In France, a country that has a legal framework, one of the most limiting factors for farmers is that the exchange of seeds is prohibited, regardless of whether they are protected, unprotected, traditional or local or whatever!

Who can improve plant varieties and with what material? *A priori*, the entire world can improve a plant using existing seeds, including those protected by a PVP. However, the utilization of an improved variety is limited. The improved variety has to be registered in the catalogue in order to be marketed. Otherwise, the variety can only be used by plant breeders and cannot be given to other farmers (even free of charge), except for the purpose of developing new plant varieties.

What conditions are required in order to be able to produce and utilize seeds from a farm? Can they be utilized for profit or not for profit? At global level, the conditions for farm seed production have become increasingly difficult in recent years. The EU and France, for example, opted for the hard line of the 1991 UPOV Convention that stipulates the obligation to pay profits to breeders and also prevents farmers from exchanging seeds, regardless of the type of seeds. Even within the programmes to develop new plant varieties, these requirements apply to all seeds/varieties and at all levels, from farmer to private sector. In the framework of a breeding programme, conservation varieties can be used as inputs. The level of investment for developing new plant varieties (empirical or using state of the art biotechnology) will depend on the levels of return on the investment and then on market size and/or the existence of public subsidies to promote them.

For farmers, the possibility of selecting seeds and developing new varieties is essential and has been essential for thousands of years. This analysis raises the following questions:

Who is the selection for? Is it for oneself or for a group?

Why select? Given the absence of a commercial variety adapted to a specific niche market demand, the applicants lack the financial means to buy seeds and expensive agricultural inputs etc.

How will the selection be organized? What if I improve or obtain new varieties just for myself? If I exchange with my neighbours or mobilize other stakeholders, from public or private research for breeding purposes, do I depend on a framework linked to the values of private marketing or to social values of innovation? In this context, participative breeding is an appropriate model to link public and private stakeholders (primarily farmers) and to share technology in the field of genetics and molecular biology.

When plant varieties are selected by and/or with farmers, different aspects should be considered. Does selection involve public research or not? Do criteria for commercialization and varietal exchange apply? These criteria relate to farmer breeders, rather than to seeds from previous farm harvests or obtained from reproducing their own seeds.

Farmers select on their own or within the framework of a participative programme if the available varieties are not suitable, either because they are too fragile or because they are poorly adapted to their objectives. Selection is generally governed by the user (or users). However, there are budgetary constraints. Selection should not be too expensive in relation to expected future profits. The organization of selection for and with farmers depends on the farmers' objectives and the national institutional constraints. In general, farmers involved in this process are not geared towards the international market. In the case of participative breeding, the work to obtain new "improved" varieties from traditional varieties is conducted within a clearly defined framework. The farmers may face high investment costs: cost-sharing within the framework of a participative breeding programme; time spent by the farmer; and mobilization of plots for the project. The compulsory registration in a catalogue and the strict conditions of registration mean that at present, in France, varieties that are modified in participative breeding projects do not comply with the criteria for approval. Consequently, they cannot be sold or, in theory, exchanged.

In the EU, some aspects of flexibility have been identified, particularly in Germany, where farmers' clubs have gained recognition. There are also similar initiatives in France (Moÿ, 2010). Club members have access to varieties developed "collectively" (this leads to a new area of analysis), a return on the common assets of a club. As a result, this analysis can make reference to the club's common varieties, which are developed collectively and with collective rights. Thus, implementing a registry of this type is conceivable at global level (FAO, ICRISAT etc.). It would make it possible to identify the varieties developed in these projects and their characteristics. This would bring them institutional recognition without necessarily providing legal protection.

Alternative soft law regulatory frameworks for protecting genetic resources

Some alternative solutions can also be implemented or promoted by groups of stakeholders (farmers, rural communities, public or private researchers, cooperatives, processors, traders, consumers etc.) involved in the use and exchange of genetic resources and in adding value to the products obtained from these resources.

The impact of these solutions depends on many factors, including the involvement of numerous stakeholders on a large scale and recognition by other stakeholders. In fact, certain proposals are sometimes blocked because it seems that they cannot be applied at global level: they lack the mechanisms for political influence to obtain recognition; they reveal gaps at legal level; they do not include all the issues relating to the management of genetic resources or traditional knowledge, which makes them ill-adapted to these specific cases.

- Globally Important Agriculture Heritage Systems – GIAHS (FAO–UNESCO)

Globally Important Agriculture Heritage Systems (GIAHS) seek to promote and conserve specific ecosystems and agricultural landscapes that have been shaped over time by different generations of local inhabitants (farmers, herders, fishermen etc.), who have developed original practices and techniques adapted to the local contexts and still used today. These systems take into account the numerous and complex interactions between species and the human practices that contribute to the development and maintenance of agricultural and associated biodiversity.

GIAHS within the UNESCO World Heritage framework has brought recognition to the sites identified, both for the resources conserved and the associated practices, thus revealing the importance of agrobiodiversity for the creation and maintenance of these agricultural landscapes. However, this recognition is not a tool for legal protection linked to the management of plant genetic resources. This recognition attributes a value to a defined geographical area, which in turn enables the promotion or development of agrotourism in these territories. In order to attribute a value to these systems within a sustainable production process, recognition gives a level of protection similar to that provided by geographical indications or collective frameworks, with the aim of obtaining world agricultural heritage identity in the different markets. As previously mentioned, this recognition does not provide protection for the basic agricultural varieties in relation to the agricultural practices that have developed with the history of agrarian societies. Consequently, basic plant genetic resources are not taken into consideration.

- Biocultural landscapes

In line with the GIAHS approach, the UNESCO World Heritage Treaty in 1992 enabled the recognition and protection of **cultural landscapes** that are created by interaction between humans and the environment, and which are an expression of the broad and intimate relationship that people have with their environment (UNESCO, 2013). Some cultural landscapes are linked to specific techniques of land use that guarantee and maintain biological diversity. Others are linked to beliefs, artistic practices and established customs that bear testimony to man's exceptional spiritual relationship with nature.

UNESCO promotes three categories of cultural landscape:

- Landscapes that are essentially evolving are those that have a social role and can be subdivided into two categories: living landscapes that continue to evolve; and relic landscapes, where evolutionary processes are non-existent.
- Associated cultural landscapes that result from the association of cultural, artistic or religious phenomena associated with the environment.
- Landscapes that are clearly defined and created voluntarily by man, such as parks and gardens.

The protection of cultural landscapes makes it possible to develop new sustainable land-use techniques, improving the natural values of the landscape. Therefore, they are useful for the conservation of biodiversity.

Consequently, in the case of quinoa, cultural landscapes are integrated with agro-ecosystems to varying degrees. Therefore, cultural landscapes interact directly with human practices in relation to the use and in situ conservation of quinoa's genetic resources and the traditional knowledge linked to the resources of biodiversity. On the other hand, they do not depend on processes of protection, valorization and the fair and equitable sharing of the utilization of these resources and knowledge. Thus, cultural landscapes constitute a tool adapted to the partial conservation in situ of quinoa's genetic diversity.

They do not constitute tools to conserve quinoa's genetic diversity in its entirety, nor to guarantee fair and equitable benefit-sharing with the countries of origin of these genetic resources. Nonetheless, these systems encourage recognition of the identity of the human practices developed in relation to specific environmental conditions, and promote values (sociocultural) that are distinct from purely monetary values.

Recognition of cultural landscapes (hence, of agro-ecosystems) ensures maintenance of the agrobiodiversity developed by farmers who adopted sustainable agricultural management practices over time, and guarantees the in situ conservation of quinoa's genetic resources. Nevertheless, cultural landscapes dedicated to conservation should be open to new knowledge and techniques and to the exchange of genetic resources.

- Open source seed licences

The open source seed licence (OSSL [3]) is the direct transposition to the seed sector of a concept initially developed for computer programmes. According to the OSSL concept, plant varieties and seeds are considered common goods in the public domain to be shared free of intellectual property rights.

Primarily, this system incorporates the varieties derived from participative and/or traditional breeding with a broad genetic base. These are well adapted in terms of their environment and the potential effects of global climate change. They include the traditional quinoa varieties cultivated in the Andean zone.

In an OSSL, the varieties mentioned do not have to comply with requirements of novelty, distinction, uniformity and stability, since they are not in the classic circuit of intellectual protection via a PVP, patent or regulation through registration in an official catalogue of cultivated varieties (Deibel, 2013).

The OSSL is complemented by the concept of "copyleft" ***[4]***, which prevents a third party from appropriating the initial variety after a slightly modification, and on top of that, OSSL maintains the improved modified variety in the system covered by the same rights and regulations (Kloppenburg, 2010).

The promoters of OSSL also propose a licence or model contract in which the beneficiaries agree to provide some free seeds produced from the variety acquired under the scheme. A licence is signed and information on all the cropping practices used is made public. The basis of integrating the copyleft concept also requires that the genetic improvements obtained should be made public. Lastly, by virtue of this licence or contract, the main objective of which is to free up access to varietal genetic resources, the contracting parties agree not to use the seeds to produce genetically modified organisms (GMOs).

Some people also propose associating the OSSL with the philosophy of open/free data in order to promote and preserve the traditional knowledge associated with traditional or modern varieties and to enable free access to the genetic sequences of these varieties to avoid patent applications. However, this scheme also has its weaknesses. Mechanisms should be developed to protect the OSSL from patent registration for specific functions in relation to plants' genes.

If the OSSL is to function properly, a wide seed exchange network must be created to encourage open exchanges between local communities, so that farmers, researchers and other stakeholders involved in varietal improvement can have access and work using open source licences.

In conclusion, the OSSL and the concepts mentioned encourage the free circulation of traditional and/or modern varieties to ensure continued innovation and improvement. Consequently, the OSSL could be an important tool for preventing a third party from appropriating a variety through a patent or PVP.

It is, therefore, an open framework that simultaneously promotes production, seed reproduction and innovation. Consequently, it can be associated with the protection of know-how and knowledge relating to the genetic materials that are freely accessible.

It is important to note that the genetic resources from the wild relatives of cultivated quinoa, as well as the traditional knowledge associated with the agricultural practices in the public domain, are included in the CBD's regulatory framework. In this regard, the OSSL only partially includes raw genetic resources and very few wild genetic resources.

Lastly, as in other systems, it is difficult to guarantee the monitoring/traceability of exchanges and the future utilization of quinoa's genetic resources to ensure that the OSSL functions properly and achieves its fundamental objectives.

Conclusions

Questioning the management of genetic resources based on the case of quinoa involves an examination of the diverse situations that arise from: the geographical origin of the genetic resources shared between various countries; the current dynamics of the global expansion of quinoa cultivation; and its multiple potential uses.

The current situation relating to genetic resources – under state sovereignty since the adoption of the CBD in 1992 – provides a specific legal framework for access and exchange that have a strong impact on use and innovation.

The main conclusion drawn from this comparative analysis is that, at the moment, there is no single existing legal framework perfectly covering all the issues related to the genetic resources and their sustainable management. This calls for an examination of the complementarity of existing legal frameworks, their potential overlaps and the possibilities of harmonization for the future.

Different regulatory instruments apply at different levels (local and international), for different purposes (genetic resources, varieties and seeds, landscapes, agricultural by-products etc.). The aim of this paper was to reflect on how the different issues at stake can be integrated, taking into account the limitations of these regulatory instruments.

An analysis of the norms and regulations related to genetic resources in the agricultural sector, particularly in the case of quinoa, involves identification of the various systems for food security.

The changing conditions for access to seeds and the options available to make the seed sector more effective and adapted to agriculture's diverse requirements will, inevitably, also depend on national public policies for developing an effective seed market capable of meeting the challenges of the international year of quinoa. This includes primarily: recognizing the work of the Andean peoples in the selection and conservation of local quinoa varieties; and maintaining and adding value to quinoa's biodiversity for the benefit of world food security and poverty reduction.

Inevitably, this process of reflection will involve in-depth dialogue between all the stakeholders (managers, users or legislators) involved in managing quinoa's genetic resources. No single solution is adapted to all the situations that arise. Thus, the stakeholders will have to either consider a new legal regulatory framework based on existing ones, or develop a completely new framework, based on compromise, with the aim of integrating the diverse points of view concerning the management of quinoa's genetic resources.

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[1] ADPIC, Part II, third paragraph relates to Geographical Indications.

[2] For example, some countries, like the United States of America or South Africa have no specific legislation for protecting geographic designations, the same that then pass for other mechanisms, like consumer protection, brands or the fight against falsifacation, through the usurpation of a designation (passing off: Kalinda, 2010).

[3] *Open Source Seed License* – OSSL quoted by K. Aoki in "Free seeds, not free beer": Participatory plant breeding, Open-source seeds, and acknowledging user innovation in agriculture, 77 Fordham L. Rev. 2275 (2009). http://ir.lawnet.fordham.edu/flr/vol77/iss5/9

[4] *Copyleft* is a general method to make a programme free (or other kind of work). The requirement is that all the modified versions and related extensions are also free. Concept created by Richard Stallman in 1983.